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ADVANCED TECHNOLOGY DISPLAY HOUSE
TECHNOLOGY IDENTIFICATION & APPLICATION

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ADVANCED TECHNOLOGY DISPLAY HOUSE

VOLUME 1

PROJECT SUMMARY AND PROCEDURES

Advanced Technology Display House

Vol. 1

Project Summary and Procedures.

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1. INTRODUCTION

During the decade of the 1970's political events and environmental concerns forced energy demand and supply into the front rank of problems requiring early resolution. One of the results has been a proliferation of interest and research in energy conservation and alternate forms of supplemental energy generation for industrial, commercial, and residential buildings. Projects demonstrating solar energy equipment and applications have been especially prominent. Primary emphasis has been on design and engineering of energy subsystems and components for retrofitting into existing buildings or incorporation into new construction of conventional buildings.

In the foreseeable future it is likely that other problems will emerge which are as critical as the energy issue, perhaps even more so, and which will pecipitate further reassessment of conventional approaches to building design and construction. High on the list are difficulties related to availability and use of water resources and shifts in the cost and availability of various types of materials. Compared to the energy subsystem, less attention has been devoted to the other subsystems which have to be integrated into the highly complex system which comprises a typical building. These vital subsystems include water supply and distribution, sewage, power and lighting, the building envelope itself and its interior appointments. Clearly, all of the above concerns are closely inter-related and demand the highest level of effort in applying any new technologies, as well as responsible social and institutional approaches, in seeking acceptable long-term solutions.

The Advanced Technology Display House (ATDH) project focuses on the single family dwelling to demonstrate innovative applications of advanced technology in meeting future needs of the building industry. In assisting NASA Ames Research Center on this project, NIAC drew upon extensive experience in multi-disciplinary data acquisition and compilation, and technical application analysis related to technology transfer, in order to develope and explore concepts to incorporate into the ultimate design for the display.

From the outset, a prime objective of the ATDH was to reduce the normal time lag between availability of new materials, processes and knowledge and their effective utilization. A house unit and related displays would be designed and constructed to stimulate and promote creative cooperation between all sections of the building industry, and public and private interests. Advanced technology applications would be displayed for all house subsystems with emphasis on systems integration to provide a functional, safe, attractive living environment while conforming to increasingly stringent standards governing efficient and economic use of all resources.

A guiding principle of the project was to present not only state-of-the-art technology application for current housing needs, but also to identify necessary technology adaptations to meet anticipated future needs.

In carrying out the above work effort NIAC employed the following methods:

A. Comprehensive data searches were made on all available computer files to compile state-of-the-art R & D and reported results in each of a number of defined technology areas

B. Through the use of the Technical Coordinator Network in the NASA Research Centers expert opinion was obtained on current and future applications potentially relavent to the ATDH objectives

C. Additional technical information and engineering data were sought through NIAC's technical advisors and consultants in key industrial sectors

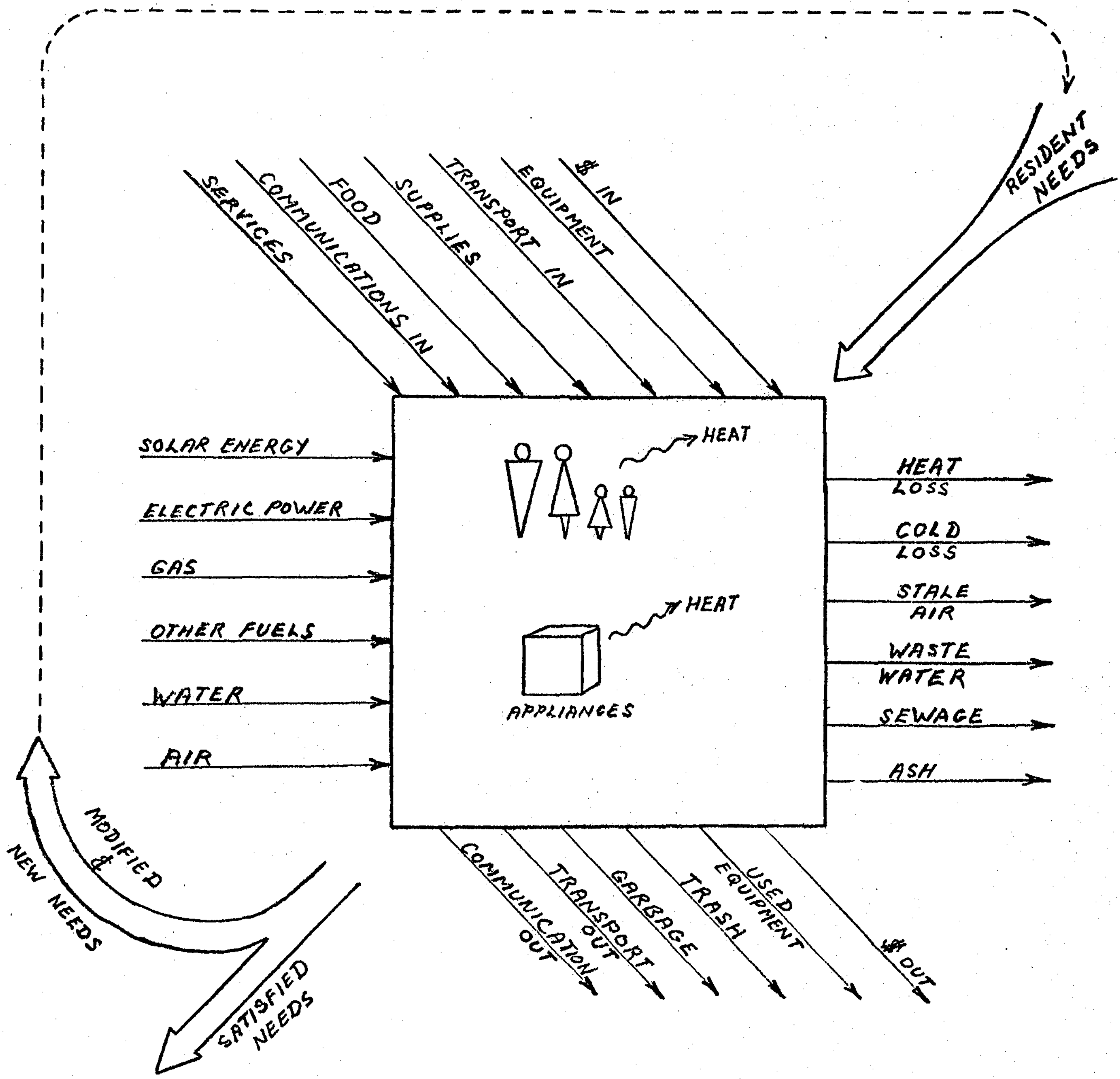
D. Combined inputs from the above sources were reviewed, evaluated and summarized by NIAC. These compilations were further subjected to expert critique by appropriate consultants

E. In the early stages of the project NIAC also identified candidate companies and organizations to assist Ames Research Center in a mail survey activity.

2. THE HOUSE AS A SYSTEM

To provide a framework for coherent exploration of multiple new technology applications to residential housing, the single family dwelling unit was conceived in terms of an engineered system.

A house may be described as an apparatus which meets basic human needs such as shelter, security, and private space for family and individual activities. It can also serve many symbolic functions related to personal identity, lifestyle, and community status. The needs of the residents generate a complex flow of commodities and services. Viewed as a system the house becomes a convergence point at which various inputs are transformed into a set of output products. This concept is illustrated by the diagram in Figure 1. Theoretically, the house system may be defined by an input/output matrix wherein every input will interact to a greater or lesser degree with every output. There are, of course, many input/outflows which can be depicted depending on the level of detail desired.



RESIDENCE / ENVIRONMENT INTERACTIONS

FIGURE 1.

Clearly, the inputs to, and outputs from, the house system will be strongly influenced or determined by external factors. Thus, the house system is actually only a small component of a much larger, more complex community and regional system which define the origin and termination points of the flows suggested in Figure 1.

The ATDH project entailed examination of the house system and selection of a number of instances where advanced technology may be applied to:

... *satisfy resident needs more efficiently*

... reduce negative impacts of the house system on its environment.

This could take the form of either quantitative reduction of specific inputs and/or outputs, or, increasing the effectiveness of specific input/output interactions.

Exhaustive study of all the possibilities for advanced technology demonstration is a major task and was beyond the scope of the present project, as was the larger issue of environmental interaction considerations. Therefore, selection of problem areas and appropriate technological alternatives for display ultimately depended on informed judgement. For this purpose, the house system concept briefly discussed above was a usefull aid in two ways:

...to highlight specific problem areas in need of a technical solution

...to provide a framework for finding areas where a given technology may be usefully applied.

3. THE CONCEPT DEFINITION PROCESS

Concepts and Criteria

Concept definition and identification of appropriate technologies for incorporation into the ATDH, proceeded in thefollowing stages.

A residence was defined in terms of an integrated set of systems designed to meet the needs of a family consisting of 2 adults and 2 children with a lifestyle governed by conventional, middle class standards.

Key system areas were defined as:

*Power generation and distribution

*Water supply

*Sewage disposal

*Waste disposal

*Building envelope

*Interior space conditioning

*Computer controlled system management .

For each key area typical usage data were examined and reconstructed with reasonable allowances for waste reduction. Appropriate technologies were investigated for meeting the modified usage scenarios which would offer a quantitative or qualitative improvement in effectiveness. The primary consideration was to avoid introducing a technology option simply for the sake of novelty.

Principle criteria employed to test applicability of any technological option were as follows:

1) Removal or reduction of hazards.
2) Maintenance and servicing of equipment no more demanding than contemporary equivalents in terms of service frequency and mechanical complexity.
3) Potential for integrating into a computer based control and management system.
4) Does technology enhance degree of autonomy of house operation with respect to power, water and sewage connections? Does technology favorably decrease interaction between the house and its environmental boundaries?
5) Overall improvement in energy demand schedule.
6) Overall improvement in water demand schedule.
7) Overall reduction in sewage and contaminated water waste output.
8) Overall reduction in solid waste output.
9) No increase in airborne particulates or gasseous pollution.
10) Potential for economic viability by 1990 era.
11) Technically deliverable prior to mid-1982.
12) Equipment and/or usage would not present a psychological threat or require major readjustment of attitudes for contemporary, conventional, middle class family members.
13) System would not constrain present life style and would be adaptable to a reasonable variety of lifestyle choices.
14) System would not constrain mobility of house.
15) System would not constrain building envelope design or construction technologies.
16) System would not violate contemporary aesthtic sensibility or be visually obtrusive.

Conformance to particular national or local building codes was not a guiding criterion. No technology was to be eliminated from future consideration. The initial objective was to select a cohesive set of technologies as a basic operational framework against which all others may be tested. Choice of specific equipment for display would conform to detailed engineering specifications which clearly define function and performance. However, the engineering criteria (to be established) would conform to the overall technology criteria envelope defined above.

Technologies for Assessment

A detailed list of potential technology options and application areas was created which ultimately became the basis of a data file for the project. This listing is presented below under the heading Technology File.

Technology File

1. On-Site Power Generation

1.1 Solar Thermal

1.2 Photovoltaic

1.3 Wind Electric Generators

1.4 Stoves and Incinerators

1.5 Heat Engines(Rankine, Stirling etc.)

1.6 Oil and Gas Powered Generators

1.7 Legal and Social Aspects

1.8 Residential Energy Demand and Usage

1.9 Thermoelectric Devices

2. On-Site Power Storage

2.1 Conventional Lead-Acid Batteries

2.2 Other Batteries

2.3 Redox

2.4 Thermal Storage(Rocks and Fluid)

2.5 Thermal Storage(Phase Change Materials)

2.6 Chemical Storage

2.7 Hydrogen Systems

2.8 Flywheels

2.9 Fuel Cells

2.10 Annual Cycle Energy Storage(ACES)

3. <u>Utility Power and Interfacing Equipment</u>

3.1 Electric

3.2 Gas

3.3 Invertors(DC/AC)

3.4 Rates and Legal Aspects

4. <u>Power Distribution and Devices</u>

4.1 Flat Conductor Cable(FCC)

4.2 Connectors, Plugs, Switches

4.3 Safety Devices, Breakers

4.4 Motors

4.5 Solid State Devices

4.6 DC vs. AC Power

5. <u>Space Conditioning</u>

5.1 Heat Pumps

5.2 Heating Systems

5.3 Air Cooling Systems

5.4 Ventilation Systems

5.5 Humidity Control Systems

5.6 Air Quality Management

6. <u>Lighting</u>

6.1 Building Design Aspects

6.2 Fenestration

6.3 Luminaires

7. <u>Water Usage, Distribution, and Treatment</u>

7.1 Water Demand and Usage

7.2 Plumbing(Conventional)

7.3 Ultraflow System

7.4 Hotwater Systems

7.5 Filtration

7.6 Purification

7.7 Greywater Recycling

7.8 Swim Pools and Spas

7.9 Grounds Maintenance and Irrigation

8. <u>Sewage Treatment</u>

8.1 Conventional Systems

8.2 On-Site Treatment(Waterless)

8.3 On-Site Treatment(Water and Other)

9. <u>Solid Waste</u>

9.1 Separation and Recovery

9.2 Compacting and Storage

10. <u>Household Computer System</u>

10.1 Energy Controls

10.2 Home Management

10.3 Security

10.4 Communications

11. <u>Appliances</u>

11.1 Food Preparation

11.2 Food Storage

11.3 House Cleaning and Maintenance(Interior)

11.4 House Cleaning and Maintenance(Exterior)

11.5 Personal Hygiene

11.6 Fitness and Health

11.7 Entertainment Systems

12. <u>Building Envelope</u>

12.1 Passive Design Features

12.2 Roofing

12.3 Walls, Claddings, and Finishes

12.4 Internal Structural Support Members

12.5 Foundations(Fixed and Movable)

12.6 Insulation

12.7 Windows and Doors

12.8 Locks, Hardware

12.9 Subsurface Space Treatments

12.10 Panels(eg. Honeycombs, Composites)

13. <u>Interior Furnishings</u>

13.1 Floor Coverings and Treatments

13.2 Wall Coverings and Treatments

13.3 Ceiling Coverings and Treatments

13.4 Fabrics and Materials

13.5 Furniture

13.6 Variable Space Partitioning

13.7 Internal Doors, Windows

13.8 Internal Locks, Hardware

13.9 Styling and Decorative Options

13.10 Intumescent Paint Applications

14. <u>Transportation and Materials Handling</u>

14.1 Storage and Servicing Facilities

14.2 Fueling/Charging Outlets

15. <u>Residential Systems</u>

15.1 ATH

15.2 Others(Tech House, Ahwatukee etc.)

15.3 Attitudes To Conservation

Initial Design Objectives

Following a brief, initial survey of technology application possibilities and in conjunction with other members of the project team we then developed an outline of design objectives for the ATDH as follows:

On-site power generation:

At least 80% self-sufficiency in total energy requirments in any climate or topographic location with capability for 100% on-site generation in high insolation areas.

Option 1: Design a core system for the San Francisco Bay Area and develope alternate plans for other possible locations using add-on equipment.

Option 2: From the beginning, design a series of compatible modules which can be arranged as required to suit the variety of conditions to be encountered.

Conventional power systems:

On-site power systems to be compatible with external sources for back up.

Option 1: Design to existing standards (115 vac, 60 cycle) so that external power is available via direct connection. On-site power would be conditioned to make compatible with external supply.

Option 2: Investigate alternate internal power standards(eg. 40 vdc) for direct tie-in with on-site power generation. External power sources will then be connected via energy storage/ load levelling/conditioning systems.

Miscellaneous energy conserving devices:

Incorporate state of the art devices where possible. Immediate market availability or cost optimization not to be a constraining factor, providing there is high confidence level that similar devices will be commercially viable within 3 years.

Internal power distribution:

Innovative use of flexible flat cabling (FFC) for maximum adaptability to various long duration and short term internal layouts.(eg. FFC under floor, or under carpet system will not be as constraining as in-the-wall conduit systems) There will be demonstrably higher standards of protection from fire and shock hazards than found in most current codes.

HVAC Equipment:

All sytems will be state of the art, be visually and acoustically unobtrusive, highly automated and require minimal servicing and maintenance. Air infiltration will be controlled to minimize intrusion of airborne dust particles and contaminants and reduce cleaning workloads.

Lighting:

High efficiency illumination sources to be employed. Layouts and designs should accomodate a wide variety of interior decor options.

Water and Plumbing:

On-site conditioning will provide the highest standards of purity and clarity of potable water. Extensive recycling should reduce contemporary fresh water usage rates by at least 75%. Fittings to demonstrate high standards of human factors, engineering in operational convenience, attractiveness and durability.

Sewage:

Full on-site sewage treatment, preferably a waterless system, with minimal service and maintenance requirements. All effluent and/or dry waste to be completely sanitized and environmentally benign.

Non-sewage dry wastes:

Convenient and efficient collection, compaction, and treatment on-site. Investigate feasibility of clean incineration.

Household Management and control system:

The computer technology which would ultimately tie all of the various systems together is to be left open to future specification for three reasons:

a) It is necessary to have an overall picture of what specific hardware is being controlled.

b) Hardware and software is progressing rapidly and too early committment is inadvisable.

c) There are several major companies with field experience underway from which accumulating experience we may benefit later on.

A major, overall design objective was to illustrate that the mandatory move into a new era of efficiency in use of space, energy, water and other resources does not decree a degradation of living standards. In fact, the display would make a positive statement that new technology applications will open up considerable opportunities to attain greatly enhanced life styles.

Interior Furnishing:

(Open to specification)

Transportation and Materials Handling:

Design should allow for integration of items such as personal transport electric vehicles, grounds maintenance equipment and other machinery which requires significant provisions for storage, recharging, and maintenance. Innovative ideas should be explored for storage, retrieval and physical handling of household supplies, food, rubbish, etc., both within the house system and at appropriate house/community interfaces.

4. PROJECT SCHEDULING AND TASK DEFINITION

Working with other project team members and drawing on data from on-going technology assessment activities, a specific set of work tasks were defined and and coordinated with a project activity flow chart and schedule. Task ares and schedules are detailed in the documents below.

YEARS

MILESTONE SCHEDULE

CENTER

RESPONSIBILITY:
APPROVAL

ACCOMPLISHMENT

PROJECT: ADVANCED TECHNOLOGY HOUSE

LEVEL

ORIG. SCHED. APPR. (DATE)

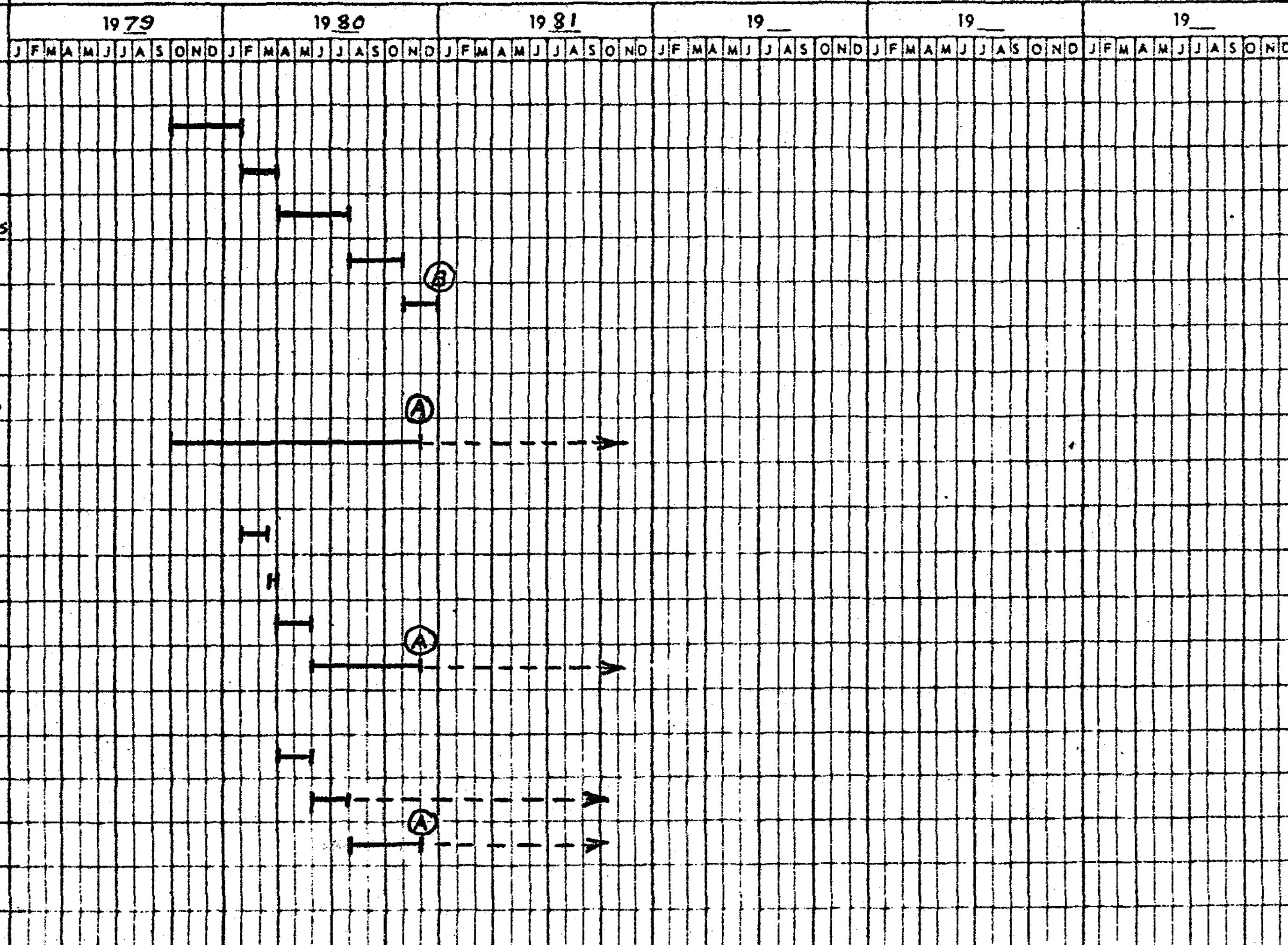
LAST SCHED. CHG. (DATE) (NO.)(INITIALS)

STATUS AS OF (DATE) (INITIALS)

MILESTONES

PROJECT PLANNING:
- ESTAB. GOALS & OBJECTIVES
- ORG. ARCH'T SELECT'N COMM.
- PREP. SOLICITATION MATERIALS
- SELECT ARCHITECT
- PRELIMINARY DESIGN

TECH. ASSESS & ENG'G SPECS:
- IDENT TECH. POSSIBILITIES
- PRIMARY SYSTEMS:
  - TECHNOLOGY REVIEW
  - PRELIM. ANALYSIS
  - ENGINEERING ANALYSIS
  - SYSTEMS DESIGN
- SUB SYSTEMS:
  - PRELIM. REVIEWS
  - DECISION FOR INCLUSION
  - DESIGN IN



NOTES:

(A) PRIMARY SYSTEMS & SUBSYSTEMS IDENTIFIED & ANALYSED FOR INCORP. IN PRELIM DESIGN DOCS.

(B) PRELIM. DESIGN DOCS COMPLETED.

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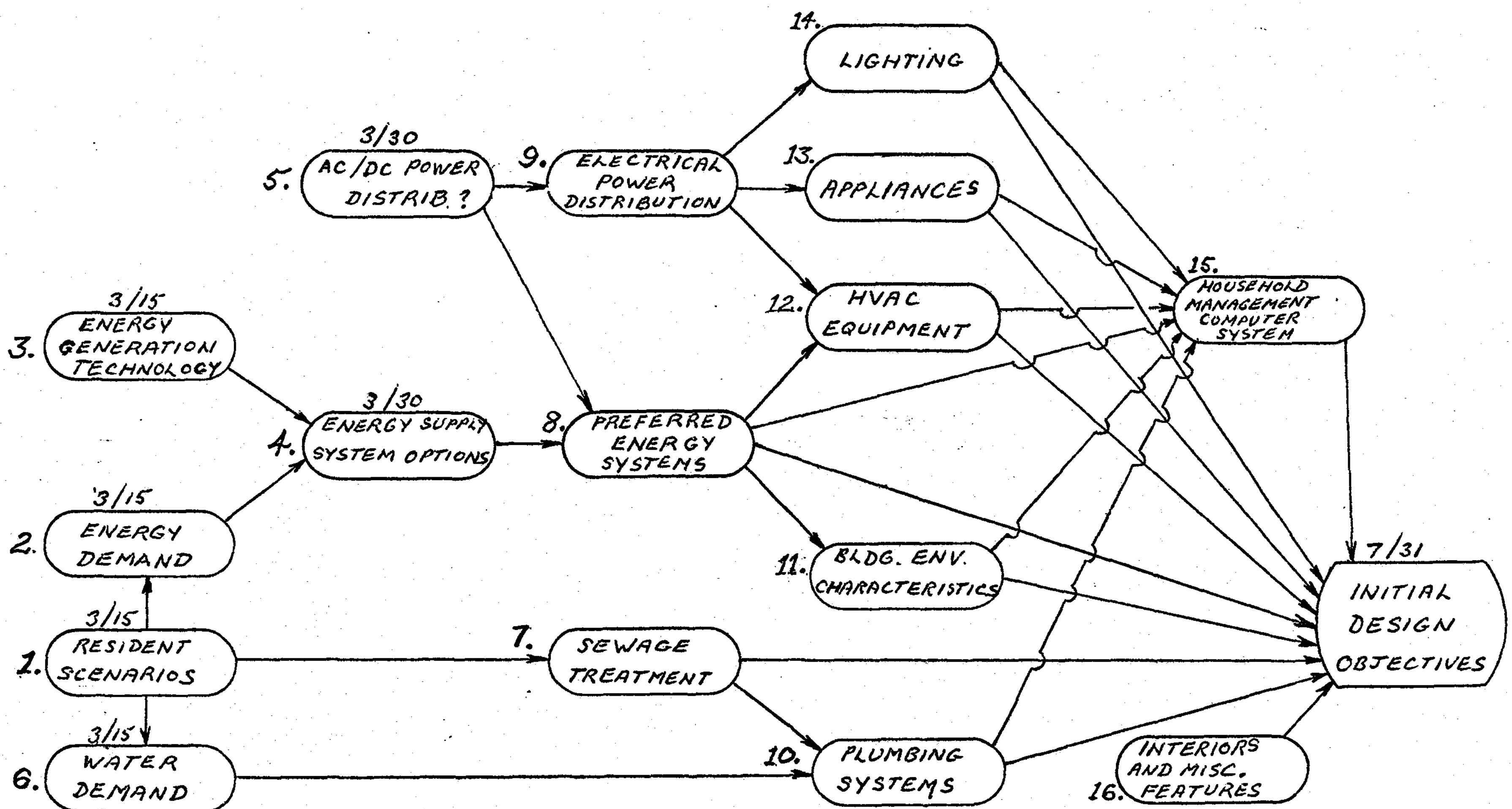
ATH PROJECT
TASK AREAS & TARGET COMPLETION DATES SCHEDULE



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TASK AREA WORK DEFINITION AND DATA REQUIREMENTS

Task 1. Resident Scenarios

Due to the unconventional features of the ATH it will be necessary to undertake an intensive analysis of energy and water demands placed on the various subsystems. The standard "rules of thumb" for conventional building design are unlikely to be adequate for the purpose. Therefore, to establish a consistent set of input data for the ATH project requires an appropriate definition of the life-style & pattern of activities of one or more sets of "residents". The description of activities should enable construction of demand profiles for all house subsystems which display hourly, daily and seasonal variations throughout a typical annual cycle.

Principle outputs will be used to determine electric and thermal energy loads, water flows and sewage treatment needs. However, the resident scenarios will also be used to determine interior layouts, furnishings, appliance needs, etc. at a later stage of the project.

Sufficient detail should be provided to enable full scale computer simulation of household activities in order to analyze effective impact on various subsystem configurations.

Task 2. Energy Demand

Requirements are aggregate energy loads and worst-day profiles (in kwh or btu) for:

- space heating and cooling

- hot water
- appliances, lights and service equipment

For preliminary analysis these data may be in the form of broad brush, informed guesses with detail refinements included as the ATH subsystems and relevant interactions are progressively defined.

Inputs to this task area will be:

- Computer format weather tapes with data on temperatures, winds, insolation, etc. for the ATH site area. Appropriate data tapes for other areas will be acquired for later analyses as the project procedes.
- Quantitative data estimates of building envelope and site characteristics for preliminary thermal load calculations.
- Ground water temperature data
- Appropriate resident activity data from the scenario definition.

Also a suitable computer program package for detailed thermal load calculations should be identified to use in subsequent analysis.

Task 3. Energy generation Technology

This task area will cover the following technologies:

- Photovoltaic cells
- Solar Thermal systems (air & fluid media)
- Wind generators
- Fuel Cells
- Other energy sources as appropriate

- Electrical storage systems
- Thermal storage systems
- Power tracking and conditioning equipment
- Utility back up systems and load levelling equipment.

For each of the above technologies data (and informed opinion) is needed on:

- Present operating and efficiency factors.
- Anticipated operating and efficiency factors (circa 1985 and beyond).
- Current acquisition costs.
- Support systems required.
- Application and installation engineering considerations (related to the ATH).
- Anticipated equipment and installation costs (circa 1985).
- Present availability, supply sources and delivery lead times.
- Identify critical items, reliability, failure sensitivity and expected service life.
- Servicing and maintenance requirements.
- Safety factors and hazards containment.
- Principle advantages and disadvantages related to the ATH objectives.

Data assembled in this task area will be used to assess the application potential for the ATH. Where possible, data should be expressed in parametric form so that a wide variety of sizes and configurations of installation may be compared.

Task 4. Energy supply system options

Data from the Energy Demand and Energy Technology task areas will be used to make an initial choice of systems packages which appear to meet the objectives of the ATH. These candidate systems will subsequently undergo detailed analysis to select the preferred system or systems for incorporation into the ATH display.

The purpose of this task area is to narrow down the wide range of system possibilities and justify the selection of candidates for detailed engineering analysis. Decision criteria will include:

- Meets 80% of estimated energy demand loads over an annual cycle
- Provides design flexibility for a modular, transportable house design
- Is reasonably adaptable to other site conditions, or, is structurally compatible with alternate systems. That is, the energy supply system should not dictate specific and peculiar structural requirements.
- Exterior components are functionally and aesthetically compatible with an urban or suburban environment.
- Is available within a 12-18 month time frame.
- Must fall within procurement cost range to be established by project budget allowances.

Task 5. AC/DC Power distribution

This task area will identify and assess the advantages and disadvantages of using direct current for all, or part, of the ATH electric power supply.

Data and expert opinion are required on such topics as:

. relative power transmission efficiencies of AC and DC current for the range of applications and power loads needed in the ATH
. impact on wiring, plugs and other distribution equipment
. effects of DC current, if any, on reducing occurrance and size of transient spikes due to motor start ups
. review of benefits available from state-of-the-art brushless DC motors compared to AC motors.
. relative safety of DC and AC power at various load levels.
. preliminary estimate of equipment modification and engineering effort to provide a DC power display for the ATH.

Task 6. Water Demand

The resident scenarios will provide inputs for constructing water use profiles and flow rates for all personal and utility purposes in the ATH. The profiles should display flow rates and quantity requirements for hot and cold water at hourly intervals during maximum use days at appropriate times of the year.

Major categories of use will be:

. Toilet flushing
. Baths and showers

- Lavatories
- Cooking and drinking
- Garbage disposal
- Dishwasher
- Clothswasher
- Utility sinks
- Irrigation and external uses

Preliminary data should assume the most efficient equipment and responsible use on the part of residents. (Later tasks will be defined to develop alternate possibilities such as waterless toilet systems, recycling systems, etc.)

Other possible water uses to be reviewed are:

- Pool and/or spa
- Service systems for solar thermal devices
- Thermal storage tanks

<u>Task 7. Sewage Treatment</u>

This task area will compile data on technology alternatives to conventional water flush toilets and sewage disposal methods. The objective is to employ on-site sewage treatment to eliminate the need for community sewer connections.

Items to be considered are:

- Fixture and devices for depositing wastes
- Waste transfer (water, oil, air, mechanical, etc.)
- Stabilization and temporary storage of waste
- Disposal of waste

Considerations are:

- Technical features, power requirements, etc.
- Vents and connections impacting the ATH structure.
- Service and maintenance requirements.
- Reliability of operation.
- Operational features.
- Capital and operational costs.
- Hazard containment.
- Environmental impacts.

At this stage it does not appear to be appropriate to consider any form of fluid or solid recovery from the waste treatment process. Therefore, effort will concentrate on the most effective means of stabilizing and disposal of wastes on-site.

Use of a garbage disposal unit places heavy loads of organic matter into waste water and makes recycling more difficult. It may be feasible to employ a sewage disposal unit (eg. incinerator) to burn organic kitchen waste also. In view of the possible tie in between kitchen and toilet solid waste disposal methods, it may be appropriate to consider garbage disposal options in the task area.

Task 8. Preferred Energy Systems

Previously identified energy supply possibilities (Task 4) will be analysed in depth to choose the best system,or systems, for the ATH.

Multiple systems may be necessary to enable the ATH to operate effectively in various site locations. However, to the extent possible, the selected energy supply systems should be interchangeable without extensive modification of the ATH structure or the other ATH systems.

The selected systems will be defined in detail and all components specified in terms of:

- overall dimensions and weight
- space and elevation requirements
- inputs and outputs required
- service and maintenance access
- security & safety measures to be provided
- other information relevant to incorporating the system into the ATH
- potential sources of supply
- any modification or other engineering that may be necessary.

In addition a preliminary plan and timetable should be developed indicating critical path items for procurement or modification.

Task 9. Electrical Power Distribution

This task area will investigate power distribution equipment for the ATH. In particular, state-of-the-art flat conducting cable (FCC) technology should be reviewed for:

- availability of cables at adequate power ratings
- compatible switchgear, connectors, plugs and sockets
- circuit breakers and safety devices

Task 10. Plumbing Systems

This task area covers all aspects of water treatment and delivery including:

- Fresh water supply
- Fresh water filtration and/or distillation
- Heating and chilling
- Plumbing
- Grey water recovery and treatment for recycling
- Disposal of used water
- Fire protection

The greywater recycling will be especially important if a sewerless toilet system is used. Even if the greywater is not reused to a significant extent it would have to be treated to a relatively high standard of purity in order to dispose of it by surface evaporation, or runoff.

A single-pipe electrically operated system such as the Ultraflow (previously described) is of interest not only for the inherent energy and water conservation features but also for the possible tie-ins with the home management computer system. This task are should identify innovative ways to exploit the potential for automatic control and computer monitoring of all plumbing features.

Task 11. Building Envelope Characteristics

This task area will summarize and provide general design guidelines to meet desired objectives of the ATH. Consideration relevant to the building are:

- Functions and activities to be accommodated,
- Operational and structural features required,
- Thermal performance required,
- Acoustic insulation requirements,
- Materials and composite panelling that may be used,
- New technology paints and protective coatings,
- Innovative devices, hardware and techniques that may be employed,
- Space, structural and access provisions for energy supply systems and servicing operations.

Information generated in the above effort will be used to develope the building specifications at a later date.

Task 12. Heating, Ventilation and Air Conditioning Equipment

Technical data is required for all types of service equipment for space conditioning including:

- High performance heat pump technology
- Variable area demand control for space conditioning
- Thermal conditioning distribution mechanisms
- Ambient atmospheric monitoring
- Humidity control
- Demand controlled ventilation
- Thermal recovery and exchange units
- Air filtration and cleaning devices

Ventilation control will be an important demonstration feature of the ATH in view of the increasing need to reduce random air infiltration and associated thermal losses in buildings. The ATH will reduce uncontrolled infiltration to a minimum in order to optimize internal conform conditions. The required turnover of air volumes should be managed by atmospheric monitoring devices to maintain air quality at all times. For this, and all other space conditioning purposes, the power and flexibility of the on-site computer will be exploited to the fullest extent.

Task 13. Appliances

Innovative, high efficiency appliances will play an important role in the ATH display because of the prominent visibility of these items.

Major functions to be addressed include:

- Food preparation
- Food storage
- Dishwashing and waste disposal
- Interior house cleaning
- External house & grounds maintenance
- Personal hygiene and cosmetic needs
- Clothes washing & drying
- Health and fitness
- Entertainment
- Power tools for hobby or maintenance work

The outcome of Task 5. will determine whether it will be necessary to engineer a compliment of appliances for DC power operation, in which case, this task will consider the applicable changes to be made. Of particular interest are the increased efficiences of state-of-the-art brushless DC motors and reducing the high transient power peaks associated with conventional electric motors.

In the event that standard AC line power is used then operating efficiencies should be analysed in conjuction with innovative devices such as the NASA power factor control circuit for AC motors.

Task 14. Lighting

Innovative features to be covered in this task area are:

- High intensity, localized lighting
- Automatic light level controls
- Automatic on/off controls
- Interior emergency lighting
- External security lighting

Depending on the recommendations from Task 5 regarding DC power distribution it may be necessary to analyze availability and performance of lighting equipment for non-standard power supplies.

Task 15. Household Management Computer Systmes

This section will review general requirements for computer hardware and software for performing the multiple monitoring and control tasks within the ATH. In addition to imputs deriving from other task areas (as indicated in the task schedule chart) the following aspects should be included:

- Detection and warnings of fire hazards
- Detection of equipment malfunction
- Detection of unauthorized intrusion
- Other security functions
- Internal information and communications
- Central time reference for all clocks & timing devices in the ATH.

- Household management assistance (record keeping, inventories, maintenance scheduling, periodic reporting of energy & water useage, etc.)
- Innovations such as voice controlled locks, etc.

The house of the future will probably have a direct satellite communications antennae for data reception, if not transmission. The ATH provides a prime opportunity to demonstrate NASA's recent developments in omni-directional antennae technology. Such options should be addressed in this task area because of the tie between the computer and communication functions. A possibility here is remote, off-site control of ATH functions, or perhaps automatic remote signaling of intrusion or malfunction within the ATH.

Present computer technology opens up an enormous array of possible uses within the ATH. A key responsibility of this task area will be to consider and specify a range of the most creative applications of interactive computer capability.

Task 16. Interiors and Miscellaneous Features

This section will consider new technology relevant to all interior appointments for the ATH, such as:

- Floor covering
- Wall & ceiling treatments
- Fabrics and decorative materials
- Furniture
- Functional hardware and fixtures

Other significant features could include:

- Central vacuum systems for cleaning and dry waste collection,
- Accumulation, storage and disposal of household garbage,
- Provision for sheltering and charging electric vehicles,

5. CONCEPT DEFINITION: ENERGY SYSTEMS

Comprehensive computer data base searches were ran covering all aspects of energy usage and technology applications research in single family dwellings reported from approximately 1970 to the present. Selected items were carefully reviewed to establish a clear picture of current state of the art. (A bibliography for the project is appended to this report) Then on the basis of:

a) the criteria previously defined

b) extensive conversations with persons identified as key experts in each field

a concept energy system for the ATDH was established. This was not intended to be a formal definition of the energy system. Rather it was a to serve as a starting point for critical discussion and approval by all project team members and other experts as deemed appropriate.

A complete description of the energy systems and underlying rationale for technology selection is contained in the companion volume to this report under the title:

ATDH PROJECT: ENERGY SYSTEM DESIGN CONCEPT.

6. CONCEPT DEFINITION: WATER & SEWER SYSTEMS

As with the energy systems, a similar effort was undertaken to develop a baseline concept for water and sewer systems for the ATDH. This work is detailed in the accompanying volume to this report entitled:

ATDH PROJECT: WATER & SEWER DESIGN CONCEPT.

As the ideas for this section of the project evolved, a number of changes occurred for the overall concept. It became clear that for an integrated system it was desirable to consider water treatment, sewage and waste disposal as component parts of a generalized "waste treatment" system. The dominant objectives forcing this integration were the need for a "sewerless" house (ie. no connections required into a sewer utility) and the need to reduce the flow of all household waste products across the house/community interface. Without a sewer line to dispose of contaminated liqiud wastes it became necessary to reduce and treat effluents to a degree suitable for surface or subsurface discharge. A highly efficient aerobic septic tank would serve this purpose, however, it would not solve the problem of removal of the various quantities of solid wastes generated by the household unit. Therefore, the ultimate waste disposal technology would seem to be a general purpose incinerating device which could dispose of all liquid and solid waste residues with the exception of metal and glass. Further enhancing the incinerator concept is the fact that a significant amount of energy may be generated by burning exothermic materials which would substantially reduce energy needed to evaporate liquid residues.

Although, an oil transport mechanism was initially considered for the sewage system it appeared on further study that the operational reliability of current systems and the expense of oil/water separation in general made them a less desirable choice. Also, the actual amounts of fluids discharged from "new technology" low flush toilet devices are not too burdensome for an incinerator disposal system.

Previous experience with incinerator technology has not been too encouraging. However, we were assured by experts involved with space craft system development that prior problems had been largely due to materials inadequate to handle some of the corrosive waste materials (especially urea salts) and also to problems of cleaning up waste gas discharges. Current know-how on materials and catalytic gas purification could now be applied to resolve the earlier difficulties.

7. THE EDUCATIONAL ROLE OF THE ATDH

As concept development work proceeded we were made increasingly aware of how much domestic energy, water and other resources usage consists of built-in wastestemming from in-grained cultural practices, habits, and attitudes. Whatever technology solutions are provided in the future, they will be ineffective without a concomitant acceptance of responsibility by all individuals to reduce waste and inefficiency. Technology ought not to be viewed as a way to sustain a "throw-away" economy.

The ATDH can play a small but valuable role in creating social awareness of the need to conserve resources. It can be particularly important in the direct impressions it makes on younger generations as well as those persons who influence them. The following concept paper provides some interesting perspectives on the ATDH as an educational facility.

OPERATION OF THE NASA ADVANCED TECHNOLOGY DISPLAY HOUSE AS AN EDUCATIONAL FACILITY

(Concept Paper)

Submitted by
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JET PROPULSION LABS. INC., JUNE 1980

INTRODUCTION

The basic thrust of the NASA Advanced Technology Display House is not to build a home that might be duplicated on today's commercial market, but rather to build an imaginative futuristic illustration of what a home in the near future could be like. The author considers this project very analogous to aspects of the 1933 World's Fair where a display of the "home of tomorrow" was presented to the public. As that exhibit demonstrated, if the imagination of the public is properly stimulated, then the commercialization of such ideas is only a matter of time.

When one considers the desired impacts of the NASA Advanced Technology Display House, it is reasonable to define this installation as a tool of learning or an educational facility. If the mechanisms of the house are to function properly, sufficient thought and time must be given to the planning and development of the individual technologies and then overall integration of these into the house. It also follows that if one wishes to achieve the desired educational objectives, goals, and impact, this same type of careful planning and development must be put into the "technology" of learning and education. The aim of this paper is to make some suggestions as to the concepts, strategies, procedures, and operation of the NASA Advanced Technology Display House to maximize the probability of obtaining these educational goals.

TARGET GROUPS IDENTIFICATION

The first step that must be done is the categorizing or definition of the various target groups to whom the Advanced Technology Display House wishes to impart educational meaning. The following groupings are given as a possible listing.

I K Through 12th Grade Students, Teachers, and Administrators

A. Primary and Elementary Levels (e.g. normally cover kindergarten through six grade).

B. Intermediate and Secondary Levels (i.e. 7th through 12).

C. In Service Training (concepts needed for training of the teachers who, in turn must work with the students)

D Administrators (make the major decisions as to what the teachers and students will be able to do)

In each of these four subgroupings, there will be some specific requirements as to certain procedures and materials which must be made available.

II Universities and Colleges

A Community Colleges

B. Vocational Training Institutions

C. Advanced University Programs (also graduate school and post graduate research)

III Trade and Professional Organizations

Two major subgroupings would probably be required under this heading.

A. Trade Organizations, Labor Unions, Etc. (emphasis might be on the vocational aspects and the how-to-procedures utilizing the advanced technologies)

B. Professional Organizations (more emphasis on the engineering aspects)

IV General Public

The fourth grouping, which may in turn may be the most important, is information for the general public. If this educational message is not properly delivered to this specific group, then the eventual market demand and political backing for the use of the advance technology in the commercial market place will not exist. This might be expressed in another way. It is obviously of extreme importance that the economics and institutional barriers be reduced to a very favorable position, but at the same time if there is not an "emotional" or political commitment on the part of the general public to have these things happen, they will not occur.

DETERMINATION OF TEACHING OBJECTIVES:

For each one of the target groups and subgroups, it is important that specific teaching objectives be defined and determined. An example for the case of the primary and elementary levels might be the interconnection between the way we live our lives, the way we use energy, and the way we employ advanced technology. Many aspects of the house will illustrate how advanced technology actually helps to conserve energy, but at the same time it is important that the inhabitant of the house develop and practice a conservation ethic.

It is felt that it would be premature at the present time to list unilaterally all of these teaching objectives. It is rather suggested that at this early stage of the program, contacts be made with key eventual user groups. For instance, contacts should be made with educators and educational groups. Initial suggestions for teaching objectives for the different sublevels of Group I would be sent to them and their comments and further suggestions invited.

Contacts should also be made with community college and vocational instructors and administrations; trade and professional organizations: and citizen groups. (The author and his associates have had some success and experience in dealing with educational user groups. The suggested procedures have proved to be very effective in the development of the National Solar Energy Curriculum for elementary schools;* these techniques are also employed widely in the field of market research.)

It is therefore suggested that the author assist the ATDH Program at this time in the development of certain lists of teaching objectives for each one of the suggested target groups and sub groups. These items would be submitted in the near future to review by "expert" individuals, organizations, and other user groups.

* See Introductory chapter of curriculum on utilization of "Teacher Consultants"

TEACHING MATERIALS, DEMONSTRATIONS, AND "HANDS-ON" ACTIVITIES

I. Teaching Materials

To achieve maximum impact with the Advanced Technology Display House, teachers and other educators will need pre visit and/or post visit materials. That is, a simple visit through the house is a stimulus, but to fully achieve the educational goals, other materials must be available. (e.g. Preparatory materials used before one visits the home as well as follow-up lessons after one leaves the home).

Material could be in the form of packets distributed through different school districts, community college, or other educational facilities. This would include teacher guides and lesson plans to illustrate to the instructor how to introduce the house, how to alert the students as to what to see, and possibly some suggested specific questions the students should seek answers for. For example, elementary students might be required to write a short paragraph about their visit highlighting one or two things of major interest to them. People in more advanced educational institutions (e.g. community college), might be alerted to look for such specific items as modern use of computers, uses of solar energy equipment, or other advance technology techniques.

Materials should be made available to instructors for follow-up lessons. These materials might be biliographies of other NASA hand-outs or government publications. There should be project handouts which the students could take away with them and then at a later date use as follow-up instructions. Such items as the "Ten-cent Hot Dog Cooker", a solar concentrator, which fourth grade students can build (Part of the National Elementary Solar Energy Curriculum) might be an example of such materials. These could be handed out to the students at the conclusion of their visit of the facility. There are numerous other projects which could be designed for students to be taken away.

It is conceivable that for the advanced students software for small mini computers might be provided. Programs that would calculate the cosine effect on solar cells, window shading by awnings, or simple energy management of a home could be provided for machines such as the Apple computer and TRS-80 (these two mini computers are the most popular ones used in home and schools).

These handout materials should be developed in an organized manner, tracking along with the basic teaching objectives which are designed as part of the overall instructional plan. The prime requisit for the materials should be that they are not only of a high educational value, but they are a good deal of "fun" to use. That is, for the advanced technology house to achieve it's educational goals, it must also be a very pleasurable experience.

Demonstrations and Hands On Activities

A visit to the high technology house should be an exciting and eagerly anticipated activity. To achieve this goal, the projects, demonstrations, and activities which the visitor will be exposed to must be very innovative and imaginatively presented. Wherever possible the demonstrations should be interactive.

In the case of the younger visiter, i.e., the elementary and junior high school student, it is suggested that a room be made available somewhere, where teachers could organize their classes; slide shows could be presented; movies exhibited; or some other hands-on activities might be carried out. (Such activities could be the utilization of the solar demonstration materials that are used in the National Solar Energy Elementary school program. These materials have proven to be exciting for children and adults.)

The room could have an outside facility or courtyard where children could experiment in the sunlight with various activities. (e.g. Children could make small solar cookers and then they could cook their lunches in the sun as part of the visit.) Other exciting materials that are available from NASA could be supplied in this area. (e.g. solar power supplies for space vehicles, and possibly a display showing how energy is conserved on a space vehicle*.) Play areas might be provided with scaled down mockups of the some items shown in the Advanced Technology Display House. This would allow the smaller children to "play" as adults in the Advanced Technology Homes that they would have in the future.

It is suggested that as a general practice, there be detailed and exciting graphics along with each of the demonstrations. These graphics might be mini computer controlled and be " talking letters". In place of standard push buttons, there could be computer voice recognition. The visitor would have to

* This type of material would also show in a very positive light how the advances made in the space effort greatly help the survival of the "space ship" Earth.

speak into a small microphone and say "start", or "open", or some other specific word to have the demonstration function. Such demonstrations might be color graphics of the functioning of different aspects of the high technology house. These graphics could be done in a three dimensional drawing (x,y,z axis on the two dimensional screen) with color coding used to illustrate hot, warm, and other flow characteristics of the system.

Another computer interactive device which all ages would have access to, could be "you design a house". In this demonstration, a house would come on the screen. Then using a light pen or some other device, the visitor could put windows and doors into the house where they desired, along with over hangs and other aspects of the house. A simulation over the day would then be carried out with the sun going through the proper path on the graphic. Depending on the window placement and overhang location, the house could either remain blue (cool inside) or gradually turn red on the inside (warm up) illustrating passive solar design parameters.

Certain rooms in the advanced technology house might be computer controlled. Sensors would realize when someone would walk in, and the computer would accordingly "greet" the visitor. The computer would then ask the visitor to make one of several choices of things they would like to see. As the visitor left the room the computer would say "goodby" and turn off the lights.

Certain very practical functions should also be illustrated. Such items might be a moisture sensor in the garden area of the house which, in turn, would feed back to a small computer. The computer would have in its memory banks the exact plants planted in different locations in the garden. Then based on the particular moisture content that individual plant should have, watering control could be carried out by the computer. This whole system could be very carefully illustrated for the viewer. It could be quite practical from the standpoint of the large ground areas or areas where there is a variety of plants that might need different amounts of water.

The experience of visiting the Advanced Technology Display House should have an integrated effect on the visitor. That is, the Advanced Technology Display House should not be a series of "one liners" but rather a continuous full story which would have maximum impact upon the viewer.

CONCLUSIONS

To achieve the maximum educational and entertainment value from the Advance Technology Display House will require careful and complete planning and development. This phase should be started at the present and not be done as a last minute activity. Coordination should be carried out now with some key user groups such as school districts, trade organizations, and other interested parties. By bringing in the suggestions and support of future user groups, the probability of success of the Advance Technology Display House will be maximized.

Full use should be made of mini computers, projects, and interactive demonstrations in the Advance Technology Display House. It is suggested that facilities be made available where educators with class room tours, organized field trips, and etc. could continue their visit activities at the Advance Technology Display House after their initial tour was completed. A room that might accommodate forty to fifty people for slide shows, movie presentations, and hand-on activities would be adequate. In conjuction with this inside facility, it is suggested that a courtyard also be provided for experimentation by the viewer in the outside sun. This courtyard could also have interactive devices such as a photovoltaically powered fountain.

The Advance Technology Display House has as its main goals the education, enlightment, and excitment of numerous types of target groups which will visit the facility over its years of existance. The planning and development of the educational aspects must be given careful and detail attention just as the technology of its operation. The viewer must not only be excited and stimulated by what he sees, but he must know the meaning and the message of what is being shown to him.

8. CONCLUSION

As concept development for the ATDH program progressed it was viewed in terms of 26 core systems area, each of which would contain a number of innovative technological features. The core systems areas may be grouped under 3 general headings:

a) power generation and distribution

b) building envelope and space conditioning

c) water supply, sewage treatment and waste disposal.

These core system areas are shown in Figure 3. below, which also indicates principle interactive links between areas. Eventually, other technology areas, not shown here, would be considered as "add-on" features. These would include such areas as furnishings, appliances, etc. which do not interact as closely with the core systems.

Also, not all core system linkages are displayed in Figure 3. For instance, there may be advantages in using low grade heat recovered from the power generation chain to evaporate certain liquid wastes thereby reducing net energy required for waste treatment. Most of these secondary links can be defined only after the major systems have been delineated in more detail.

The following descriptive data will need to be determined for each of the system areas identified in Figure 3.

Hardware: Components and accessories to provide desired outputs and performances.

Software: Appropriate internal operating logic for the system.

Controls: Manual and automatic actuating mechanisms.

Sensors: Monitoring devices for internal and external data flows, programmed schedules, etc.

Maintenance: Service requirements and maintenace proceedures.

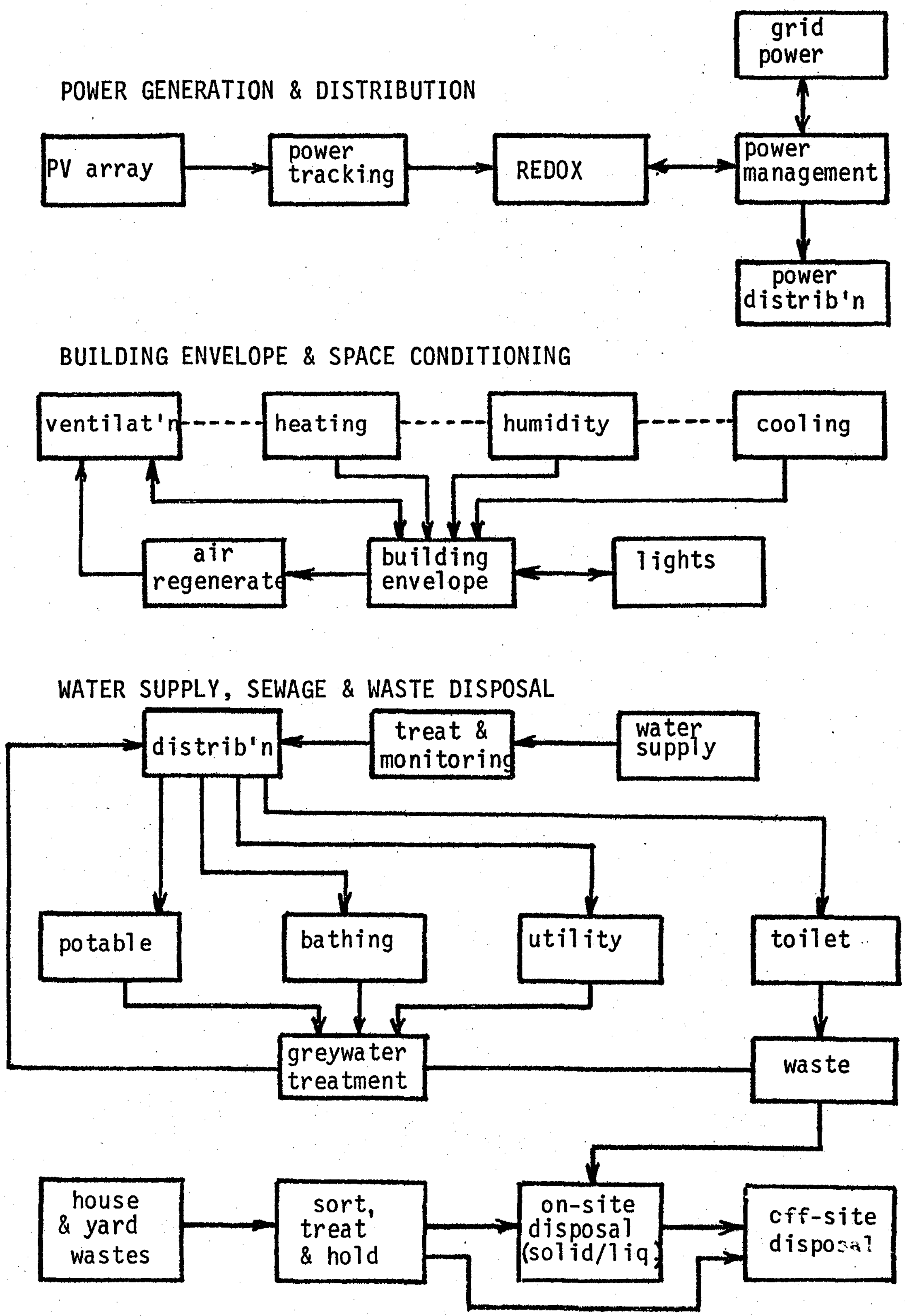
Power: Types and ratings of energy inputs.

Energy Usage: Energy required to provide specified range of operational performance.

Entropy: Comparative quantity and grade of energy inputs and outputs with estimated recovery potential. (eg. electric power input= useful work + heat and mechanical losses + low temperature heat recovery.).

Figure 3.

ATDH SYSTEMS COMPONENTS



The one key technology area not indicated in Figure 3 is that related to computer controlled system management. This system is implicitly integrated into all of the others. However, its integrating function cannot be specified prior to definition of the other core systems. The major decision to be made here is the degree of distributed or centralized control to be allocated between systems.

Other participants were engaged by program management to undertake engineering design of the key subsystem areas contained in the power generation, water supply, sewage and waste disposal, and computer management systems. We commenced to identify and assess technologies appropriate to the building envelope and space conditioning systems. Our efforts were directed to studies of:

* air quality monitoring, regeneration, and control
* hybid photovoltaic/thermal energy concepts
* thermoelectric device applications
* dynamic envelope systems (automatic, variable thermodynamic characteristics

It immediately became clear that the optimal approach was to work very closely with the project architect due to the highly interactive nature of the envelope and space conditioning systems. Thus, our "technology assessment" role became subordinate to the "technology coordination" role. For instance, in discussion with the architect some ambitious objectives evolved such as designing a structure that would require drastically reduced energy inputs. Clearly, if this could be achieved it would have a mojor impact on sizing of all power related systems. So, with the concurrence of project management we concentrated on working with the architect team to explore various technology possibilities and help generate some general ideas for structural concepts. This include setting up visits with local aerospace companies to observe production techniques, materials usage, etc. These trips produced some valuable insights. Of particular importance were ideas generated from close observation of commercial aircraft interior appointments, including latching mechanisms, imaginative ways for securing and storage of articles in tight spaces, and food preparation and service procedures. Also intriguing were ideas for exploiting hydraulic power actuating mechanisms and associated technology for some of the residential systems.

Another topic which we surveyed was the psychological influence of environmental factors such as interior space dimensions and layout, color and texture of surfaces, air flow and lighting. It is generally known that such factors can significantly affect perceptions of environmental quality, emotional states of stimulation or relaxation, sensations of hotness or coldness, and similar aspects of habitability and comfort of interior surroundings. While we uncovered numerous research reports and articles which have a bearing on these issues there was not much of immediate practical value. Most of the material concerned development of quite basic points of psychometric theory. It was interesting to notethe general lack of follow-up and evaluation studies of building concepts and ideas after they had actually been built and occupied. There appears to be a need for more practical experimentation and research in this entire field.

In developing a creative approach to meshing desirable envelope features with advanced technology options an area of particular interest is the feasibility of providing variable characteristics for the house shell. This would enable continuous adjustment for an optimal match between interior and exterior environments at all times. This is in contrast to current technology which has a "fixed" design, i.e., a stable envelope which provides the best overall compromsie to cover conditions anticipated to be met throughout seasonal cycles during the life of the structure. Such a feature may be implemented with relatively simple techniques, but does require extensive analysis of performance enhancements and impacts on other house systems to measure the net quantitative and qualitative value.